

Medical Science

To Cite:

Godlewski P, Gwóźdź-Broczkowska A, Górecki B, Hassan A, Hassan S, Bienia S. Plant-based diets in chronic kidney disease: Potential benefits and risks in renal function management. *Medical Science* 2024; 28: e145ms3466
doi: <https://doi.org/10.54905/disssi.v28i154.e145ms3466>

Authors' Affiliation:

¹Cardinal Stefan Wyszyński University in Warsaw, Wóycickiego 1/3, 01-938 Warsaw, Poland

²Medical University of Silesia, Medyków 18, 40-752 Katowice, Poland

*Corresponding Author

Cardinal Stefan Wyszyński University in Warsaw, Wóycickiego 1/3, 01-938 Warsaw, Poland
Email: p.godlewski@student.uksw.edu.pl

Contact List

Paweł Godlewski	p.godlewski@student.uksw.edu.pl
Anna Gwóźdź-Broczkowska	annagwozd@interia.pl
Bartosz Górecki	113059@student.uksw.edu.pl
Aisha Hassan	114039@student.uksw.edu.pl
Sara Hassan	sara.hassan2605@gmail.com
Szymon Bienia	szymonbienia1@gmail.com

ORCID List

Paweł Godlewski	0009-0004-9935-4091
Anna Gwóźdź-Broczkowska	0009-0005-4839-5261
Bartosz Górecki	0009-0008-9524-7263
Aisha Hassan	0009-0001-5078-7724
Sara Hassan	0009-0009-3297-8250
Szymon Bienia	0009-0000-7632-5125

Peer-Review History

Received: 28 August 2024
Reviewed & Revised: 31/August/2024 to 26/November/2024
Accepted: 30 November 2024
Published: 03 December 2024

Peer-review Method

External peer-review was done through double-blind method.

Medical Science
pISSN 2321-7359; eISSN 2321-7367



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Plant-based diets in chronic kidney disease: Potential benefits and risks in renal function management

Paweł Godlewski^{1*}, Anna Gwóźdź-Broczkowska¹, Bartosz Górecki¹, Aisha Hassan¹, Sara Hassan², Szymon Bienia²

ABSTRACT

A slow decline in kidney function characterize chronic kidney disease (CKD), which impacts about 10% of the global population. Dietary methods, particularly plant-based diets (PBD), are gaining popularity as a possible means of managing the illness, given the limited availability of existing therapy choices. The primary objective of this review is to evaluate the impact of a plant-based diet on the health of patients with CKD and its potential role in slowing disease progression. This review is based on an analysis of literature from 2019 to 2024, selected using keywords such as "plant-based diet", "vegetarian diet", "chronic kidney disease and vegetarian diet", "chronic kidney disease and plant-based diet". It includes the findings of clinical studies, systematic reviews, and meta-analyses. Results suggest that limiting animal protein in favor of plant protein may positively affect kidney function by reducing filtration load and improving metabolic parameters in CKD patients. A PBD, rich in antioxidants and anti-inflammatory components, may support kidney health, though it requires careful balancing to avoid deficiencies in vitamins and minerals (e.g., B12, D, iron). The reason for this emphasizes the need for additional study to confirm the long-term benefits of a plant-based diet for CKD patients.

Keywords: Chronic kidney disease, nutrition, plant-based diet, vegetarianism

1. INTRODUCTION

Chronic kidney disease (CKD) affects more than 10% of individuals worldwide and is a major health issue (Zarantonello and Brunori, 2023). The KDIGO 2012 guidelines describe CKD as a structural or functional kidney disease that affects a patients' health and lasts for at least three months. A reduced glomerular filtration rate (GFR) of less than 60 ml/min per 1.73 m² characterizes CKD (Valim et al., 2022). Healthcare professionals determine the severity of CKD and the risk

of consequences by measuring albuminuria levels and GFR. A gradual deterioration in kidney function is the hallmark of this illness, which can result in the buildup of toxins in the body, electrolyte abnormalities, hypertension, and other consequences.

Because CKD is a progressive disease, researchers and clinicians are continually looking for strategies to slow its course and alleviate symptoms. Because it may improve the health of patients with CKD, the function of diet—particularly, a PBD—has attracted more attention in recent years (Cigarrán et al., 2022). Although there is no precise meaning for the term plant-based diet, it often refers to a diet composed chiefly of plant-based foods, with occasional minor portions of meat, fish, or other animal products. On the other hand, a vegetarian diet in the traditional sense may include dairy and eggs, but it avoids meat and fish (Zarantonello and Brunori, 2023).

The three main risk factors for CKD are metabolic syndrome, diabetes, and high blood pressure. Vegetarian diets minimize the risk of metabolic and cardiovascular disorders, which may assist lessen the chance of developing CKD, compared to omnivorous diets (Liu et al., 2019). Plant-based diets have become increasingly popular in recent decades for moral and health grounds. Many people view a plant-based diet as reflecting who they are, expressing concerns about environmental preservation, animal welfare, or their health rather than just a restrictive eating pattern (Hargreaves et al., 2021). Theoretically, a PBD would not seem appropriate for people with CKD because it contains high levels of potassium and phosphorus, which are not desired for this patient population.

Recent research suggests that consuming less animal protein and more plant protein can improve patients' lipid profiles and metabolic indices, while also reducing the renal burden from filtration processes. When taken in their natural state, plant products are high in antioxidants like vitamins C and E, which assist the body fight off free radicals and may even affect the immune system, successfully reducing inflammation (Liu et al., 2019; Hargreaves et al., 2021). This study aims to review research on the effects of a plant-based diet on kidney function in patients with chronic kidney disease CKD and to assess whether a plant-based diet can slow disease progression, prevent CKD development, and reduce the risk of complications.

2. METHODOLOGY

We utilized readily available medical resources, such as PubMed and ScienceDirect, using keywords like "plant-based diet", "vegetarian diet", "chronic kidney disease and vegetarian diet", "chronic kidney disease and plant-based diet". To examine the effects of a plant-based diet on kidney function in individuals with chronic kidney disease CKD, the review included articles published between 2019 and 2024 that were chosen based on abstracts and titles. The review includes clinical research, systematic reviews, and meta-analyses on CKD patients who ate a plant-based or vegetarian diet. Excluded were studies that did not specifically address how a plant-based diet affects renal function and publications written in languages other than English.

3. RESULTS & DISCUSSION

Plant-Based Diet

Animal protein may be detrimental to kidney function, according to numerous studies conducted in recent years because plant proteins promote hyperfiltration to a lesser degree, a diet high in plant products may have preventive effects and decrease the progression of CKD (Kalantar-Zadeh et al., 2020). Because of this, PBD offers CKD patients a potentially effective treatment option. PBD encompasses all diets that are mostly plant-based, but may also contain goods produced from animals. Examples of less restrictive vegetarian diets include pesco-vegetarianism, which excludes meat but allows fish; lacto-ovo-vegetarianism, which allows both dairy products and eggs; and lacto-vegetarianism, which includes dairy products but excludes eggs.

Flexitarianism, which is plant-based but occasionally allows for meat intake, is an even more adaptable form (Hargreaves et al., 2021; Świątek et al., 2023). The "Plant-Dominant Low-Protein Diet" (PLADO) and the "Plant-Based Diet for Patients with Diabetes and Chronic Kidney Disease" (PLAFOND) are two distinct plant-based diet patterns created for people with chronic kidney disease. Through individualized nutritional support that addresses the unique requirements of CKD patients, both diets seek to halt the progression of renal disease (Narasaki et al., 2023). Diets like the Mediterranean and DASH (Dietary Approaches to Stop Hypertension) limit meat consumption and emphasize plant-based foods including fruits, vegetables, whole grains, legumes, and nuts, can also be classified as PBD (La-Fauci et al., 2020; Guo et al., 2021).

An intriguing illustration of PBD is the diet of those in "Blue Zones", which are parts of the world where people frequently live to old ages. These regions have different dietary preferences, but they all have a high consumption of unprocessed foods and a low

consumption of animal products (Aliberti et al., 2024). A vegetarian diet positively affects various aspects of overall quality of life, including physical, social, environmental, and mental health (Świątek et al., 2023). In Table 1, various dietary patterns are summarized.

Table 1 Diet Types and Their Characteristics

Diet Name	Characteristics
Lacto-vegetarianism	A vegetarian diet that allows dairy products but excludes meat and eggs.
Lacto-ovo-vegetarianism	A vegetarian diet that permits both dairy products and eggs but excludes meat.
Pescetarianism	A diet that excludes meat but allows fish, making it a less restrictive form of vegetarianism.
Flexitarianism	A primarily plant-based diet that occasionally allows meat.
Low-Protein Plant-Dominant Diet (PLADO)	A plant-based diet designed for patients with chronic kidney disease, aiming to slow disease progression by limiting protein intake.
Plant-Based Diet for Diabetes and CKD Patients (PLAFOND)	A plant-based diet tailored for patients with diabetes and chronic kidney disease, providing specific nutritional support.
Mediterranean Diet	A diet based on a high intake of vegetables, fruits, whole grains, legumes, and nuts, with limited meat consumption; known to be heart-healthy.
DASH (Dietary Approaches to Stop Hypertension)	A plant-centered diet emphasizing whole grains, vegetables, and fruits, created to reduce blood pressure and improve cardiovascular health.
Blue Zones Diet	A dietary pattern focused on unprocessed foods with a low intake of animal products, practiced in regions where people tend to live longer.
Vegan Diet	A diet based solely on plant-based foods, excluding all animal-derived products, including meat, dairy, eggs, and honey; often followed for health and ethical reasons.

The Impact of Plant-Based Diets on the Risk of Chronic Kidney Disease

Studies show that PBD reduce the risk of CKD and are associated to lower rates of diseases like diabetes, hypertension, and obesity. Nevertheless, randomized controlled trials to validate these advantages are still lacking despite encouraging results from observational studies (Zarantonello and Brunori, 2023). Higher total daily protein intake (TDPI) and animal-derived protein are linked to lower

glomerular filtration rates (GFR) and higher serum creatinine levels, according to a study done on 5,889 people. These findings suggest that animal protein may have a detrimental effect on kidney health (Vukovic et al., 2023). A vegan diet was linked to a decreased incidence of CKD than an omnivorous diet in a different study with 55,113 participants (Liu et al., 2019).

Not all plant-based foods are inherently healthful; food quality is essential. Plant-based diets can include nutrient-dense whole foods or heavily processed options that are high in refined grains, sugars, and salts. An Australian study of 2,060 people validated this, demonstrating that a healthy plant-based diet is linked to lower blood pressure, waist circumference, and BMI, but a bad plant-based diet raises the risk of CKD (Stanford et al., 2024). People with diabetes may have a lower chance of developing CKD if they follow a vegetarian diet. This diet can lessen the risk of type 2 diabetes, which lowers the possibility of CKD, thanks to features including a low glycemic index, a high fiber content, and a low salt intake (Liu et al., 2019).

Protein-Energy Status in Chronic Kidney Disease

Both malnutrition and overnutrition can negatively impact the health of a patient with CKD. It is commonly known that an excess of protein can cause "intoxication" which raises intraglomerular pressure and causes hyperfiltration. Higher protein intake has been linked in studies to a quicker drop in estimated GFR. Notably, the kind of protein is just as important as its quantity; animal proteins accelerate the decline of kidney function (Zarantonello and Brunori, 2023). Protein-energy wasting (PEW), a disorder in which the body loses protein and energy over time, is another risk factor for CKD patients.

Protein-energy wasting (PEW) can result from several factors, including insufficient dietary intake, increased protein breakdown (catabolism), and protein loss in the urine due to an impaired kidney filtration barrier. PEW has serious repercussions, including diminished quality of life, increased vulnerability to infections, and weight loss and muscle weakening. PEW affects fewer than 2% of patients in CKD stages 1–2 but rises to 11–46% in stages 3–5, making it a significant predictive factor of death in CKD patients. Its incidence develops in tandem with the course of the disease (Mansouri et al., 2024). Plant protein has been the subject of continuous discussion, especially to its bioavailability and ability to satisfy bodily requirements.

According to a study, a well-balanced plant-based diet that relies on a variety of protein sources can supply all essential amino acids and completely fulfill the body's protein needs without running the danger of malnutrition, even if animal proteins have a higher bioavailability (Wathanavasin et al., 2024). It should be mentioned that even healthy people who choose to follow a vegetarian diet, particularly a vegan one, may be more susceptible to deficits in some critical micronutrients, these usually consist of iron, zinc, iodine, vitamin B12, and vitamin D in vegetarian diets. As a result, those who eat a plant-based diet ought to make sure their meals are balanced and think about taking supplements (Neufingerl and Eilander, 2021).

Protein Intake Recommendations in Chronic Kidney Disease (CKD)

Hyperfiltration, a condition in which the kidneys work too hard to eliminate byproducts of protein breakdown, is linked to a high-protein diet. From a hemodynamic standpoint, this entails increased intraglomerular pressure and afferent arteriole dilatation. These procedures eventually deteriorate kidney function by causing fibrosis and nephron loss. According to research on animals, eating a lot of protein raises the production of cytokines like TGF- β and TNF- α that promote inflammation and fibrosis (Sakaguchi et al., 2023). According to the KDIGO 2012 guidelines, people with CKD and a GFR of less than 30 ml/min per 1.73 m² should consume no more than 0.8 g of protein per kilogram of body weight per day (Sakaguchi et al., 2023).

More specific recommendations are given in the KDOQI guidelines: a low-protein diet (0.55–0.60 g/kg per day) or a very low-protein diet (0.28–0.43 g/kg per day) supplemented with ketoacids or amino acid analogs (sVLPD) is advised for metabolically stable patients without diabetes whose GFR is less than 30 ml/min per 1.73 m² (Mocanu et al., 2021; Sakaguchi et al., 2023). Organic compounds with carboxyl and ketone groups that can undergo transamination to become amino acids are known as keto analogs. Protein consumption should not exceed 0.6–0.8 g/kg of body weight per day for people with diabetes and chronic kidney disease (CKD) (Mocanu et al., 2021).

Hyperkalemia and Hyperphosphatemia

Although a plant-based diet offers many health benefits, healthcare providers have long recommended that people with CKD limit their intake of fruits and vegetables due to the increased risk of hyperkalemia or elevated potassium levels in the blood. Potassium is abundant in various plant-based meals, including almonds, tomatoes, and bananas, but meat, fish, canned foods, and processed meals

also contain significant potassium levels. The body absorbs roughly 50–60% of potassium from fruits and vegetables, 80% from animal products, and over 100% from highly processed foods, depending on the type of food ingested (Sakaguchi et al., 2023).

Plant-based diets are also high in fiber, which decreases potassium absorption and speeds up intestinal transit. In general, phosphorus is higher in plant-based foods than in animal-based ones. Nonetheless, research has indicated that a PBD may cause CKD patients' serum phosphorus levels to drop. Plant-based phosphorus, which primarily exists as phytate, has a far lower absorption rate. Because the human intestine lacks the enzyme phytase, which breaks down phytate, phosphorus absorption from these sources does not surpass 50% (Wathanavasin et al., 2024).

Fiber

Carbohydrates that avoid digestion and pass through the large intestine undigested makeup dietary fiber, which promotes general health. Fiber is naturally found in whole grains, nuts, seeds, legumes, fruits, and vegetables, but it is also available in supplement form (Cigarrán et al., 2022). Bacteria in the large intestine ferment fiber to produce short-chain fatty acids (SCFAs) like butyrate, acetate, and propionate. These SCFAs fortify the gut barrier, preventing pathogen penetration and having potent anti-inflammatory properties (Narasaki et al., 2023). Patients with chronic kidney disease frequently exhibit gut dysbiosis or an imbalance in the gut microbiota. A diminished number of helpful microorganisms is a characteristic of this illness.

Variations in the gut microbiotas' makeup encourage the synthesis of harmful compounds, including trimethylamine oxide (TMAO), which worsens inflammation, quickens the course of chronic kidney disease, and raises the risk of cardiovascular disease. Thus, implementing a plant-based diet or other diet that restricts the development of TMAO may be a potential strategy to reduce symptoms and halt the progression of CKD in patients (Wiese et al., 2021). Research indicates that diets high in fiber and low in processed foods and protein may have preventative effects, supporting improvements in blood pressure, body weight, glucose regulation, and lipid profile (Cigarrán et al., 2022). Fiber consumption may help lower blood pressure by influencing arterial contraction, relaxing the smooth muscle in blood vessel walls, and reducing the activity of the angiotensin-converting enzyme (ACE) (Narasaki et al., 2023).

Metabolic Acidosis

Metabolic acidosis is a common acid-base imbalance in people with chronic kidney disease. The body accumulates acids due to the kidneys' diminished capacity to remove hydrogen ions and produce bicarbonate. Because it triggers the renin-angiotensin-aldosterone system, which puts additional strain on the kidneys, and because it increases endothelin-1, which worsens inflammation and kidney damage, metabolic acidosis harms the progression of CKD (Sakaguchi et al., 2023). In contrast to sodium bicarbonate, plant-based diets (PBD) can restore metabolic acidosis without increasing blood pressure or causing sodium retention, making them a potentially effective therapeutic option (Sakaguchi et al., 2023). Eating meat, mainly processed meat, directly worsens metabolic acidosis in CKD patients, while consuming plant proteins actively supports a healthier acid-base balance, improves survival rates, and slows CKD progression (Mocanu et al., 2021).

Plant-Based Alternatives to Animal Products

Interest in leading a healthy lifestyle is growing in many ways, and more people are opting for plant-based diets because they believe they are better for the environment and their health. Various items have surfaced as plant-based substitutes for conventional animal-based products in response to the ever-increasing interest in plant-based eating. Although popular because of their convenience and alleged health benefits, precooked meals, plant-based protein sources, and ready-made vegan dishes frequently contain flavorings, colorings, and preservatives, which raise concerns about their actual nutritional value and potential health effects, particularly for those with kidney diseases (D'Alessandro et al., 2022). People who assume plant-based foods are always low in calories and healthy can be misled, as many of these products are high in simple sugars, fats, and sodium, with calorie counts ranging from 210 to 500 kcal per serving (D'Alessandro et al., 2022).

4. CONCLUSIONS

A plant-based diet could be a helpful treatment option for CKD patients. Research shows that replacing animal protein with plant protein improves kidney function by lowering filtration load and minimizing hyperfiltration processes, which delay the course of illness. Furthermore, a plant-based diet encourages changes in lipid profiles and metabolic indices, which may lower the long-term risk of problems. A plant-based diet for CKD patients can increase the risk of deficiencies in important nutrients like iron, zinc, iodine, vitamin B12, and vitamin D.

To avoid this, meals need to be carefully balanced, and supplements may be necessary. Additionally, when consumed in excess, processed plant-based products which are frequently heavy in preservatives, simple sugars, fats, and sodium can have a detrimental impact on the health of those with chronic kidney disease. For CKD patients, a plant-based diet shows promise as a beneficial approach, with the potential to improve health outcomes and slow disease progression. However, more research is needed to fully understand its long-term effects.

Author's Contributions

Conceptualization: Paweł Godlewski, Anna Gwóźdź-Broczkowska

Methodology: Sara Hassan, Bartosz Górecki

Formal analysis: Szymon Bienia, Aisha Hassan

Resources, data curation: Anna Gwóźdź-Broczkowska, Bartosz Górecki

Investigation: Paweł Godlewski, Bartosz Górecki

Writing – original draft: Paweł Godlewski

Writing – review & editing: Aisha Hassan, Szymon Bienia

All authors have read and agreed with the final, published version of the manuscript.

Informed Consent

Not applicable.

Ethical approval

Not applicable.

Funding

This study has not received any external funding.

Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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